THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

John Stark, a veteran in the crushed-stone industry, operates six limestone quarries in the southeastern corner of Kansas. He uses a portable plant to crush and wash the blasted stone at each of his quarry properties until adequate stockpiles of various sizes of limestone are accumulated.

Although some of the quarries are 60 miles apart, the work of dismantling, loading, moving, and reassembling the plant equipment requires a remarkably short time—from two to six days depending on the distance of the move.

The deposits in the Stark quarries are principally Fort Scott limestone. After a 7-ft. overburden is removed with a Cat dozer, 3½-in.-diameter holes are drilled 16 ft. deep into the limestone, in staggered rows. They are loaded with a combination of Gelamite® 1 and Hercol* powder on a ratio of 0.85 to 0.95 lb. per cu. yd. of solid material. Results from blasting are consistently satisfactory.

More complete details about this unusual business enterprise are presented in the article beginning on page 71.

° ° °

To speed up the work details in driving raises in the Greenwood Mine of Inland Steel Company at Ishpeming, Michigan, the mine management decided to have a 3-in.-diameter hole drilled up the center of a raise. This hole provided a means for hoisting staging and drilling materials and eliminated hand hoisting. Also, it was utilized as a relief hole in a burn-cut round.

The burn-cut round included the relief hole in the center and outside holes on the perimeter of a 4-ft. circle. Six other holes were 12 in. from the burn-cut holes. Each hole was loaded with Gelamite 1 primed with a Hercules® Delay Electric Blasting Cap. The loading ratio was 25 lb. per 1 ft. of raise. Results were excellent.

EDITORIAL STAFF: JOSEPH I. HORTY, *Editor;* JAMES J. O'NEILL, *Assistant Editor;* GERTRUDE A. DONNELLY, *Associate Editor;* EDWARD L. GRANT, *Art Editor;* HOWARD B. DICKSON, *Production Manager;* CHARLES E. RABENOLD, *Advertising Manager;* MONTGOMERY R. BUDD, *Director.*

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Views and opinions expressed by the authors of articles in this publication are their own, and they do not necessarily represent those of the publisher.

For a factual summary of the procedures followed please turn to page 77.

° ° °

A granite quarry near Henderson, North Carolina, has been in almost constant operation since its opening in 1835, using the bench method of drilling and blasting. When the present operator, Greystone Granite Quarries, Inc., took over the quarry in April, 1944, it was decided to discontinue the bench method and to blast sections of the entire quarry face at one time. The height of the face ranges from 167 to 172 ft.

An example of Greystone's present method of blasting shows 14 holes, 6 in. in diameter, drilled on 18 to 23-ft. centers. The spacings varied because of irregularities in the face. The holes were loaded with a combination of explosives charges consisting of Kanex* 2-H and Tritex®, and the blast was fired with a Titan* Blaster. Excellent results were realized.

A resumé of the activities of this progressive crushed-stone organization is given in the article on page 81.

° ° °

One of the most courageous feats in World War II was the capture of the bridge across the Rhine River near Remagen, Germany, by a small detachment of American troops in the face of desperate enemy attempts to blow it up.

The German Army had made careful plans for demolishing the bridge. The quick work of the Americans in foiling these plans provides interesting material in the use of explosives, both from a tactical and a technical standpoint.

For more facts about the heroic actions of our troops at Remagen bridge on March 7, 1945, please turn to page 88.

*Hercules Trademark

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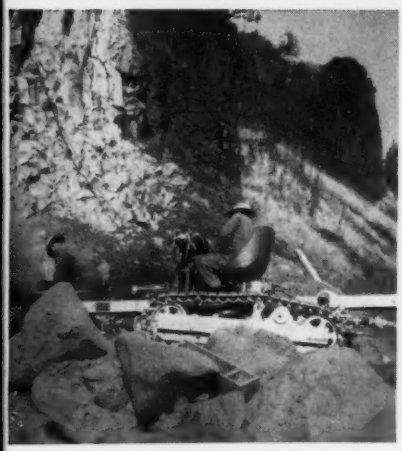
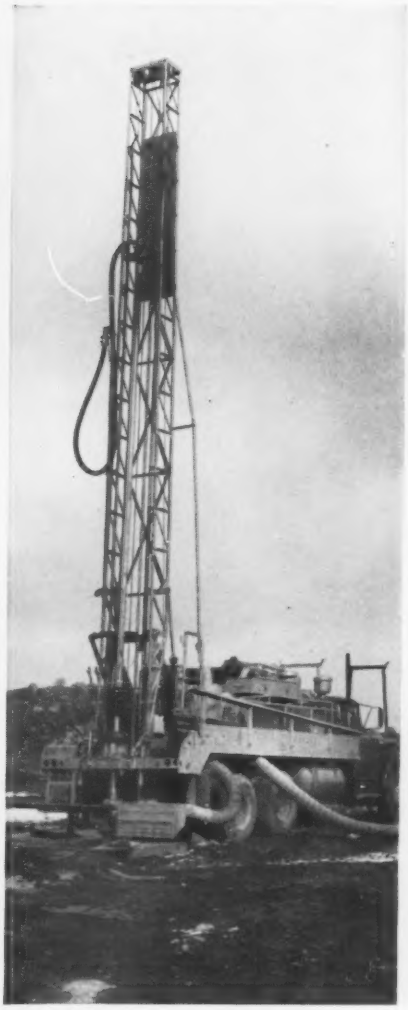
A 5½" hammer wallop. Here's deep hole drilling power in a class by itself. Gardner-Denver DH143 fills the rock drill gap between wagon drill and rotary rig.

DEEP HOLE PUNCH BLAST HOLE DRILLS



New mobility in an old quarry favorite. This new deluxe model of "Air Trac"® provides complete power positioning for all vertical, horizontal and flat lifter holes from centralized controls.

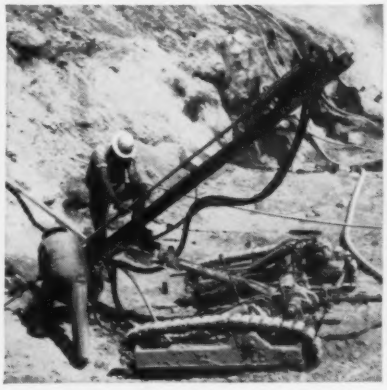
Lightweight combination. Easily handled drilling power for fast, clean holes with Gardner-Denver FL48 and FL58 air feed leg drills.



In-the-hole power for rotary rigs. New, hard-hitting Gardner-Denver "Mole-Dril"* rides with bit through rock, delivers more foot-pounds of energy to the bit than any other drill of its size.

*Trade-Mark

Air power for all drills. And plenty of it when you put water-cooled, all-weather Gardner-Denver rotary portables on the job. Five models from 125 to 900 cfm.



Long-life drill steel. Gardner-Denver sectional rods, couplings, ring seal shank . . . cut drilling costs . . . reduce steel breakage. Carburizing produces hard case . . . soft, tough core structure. Shot-peening increases fatigue resistance.

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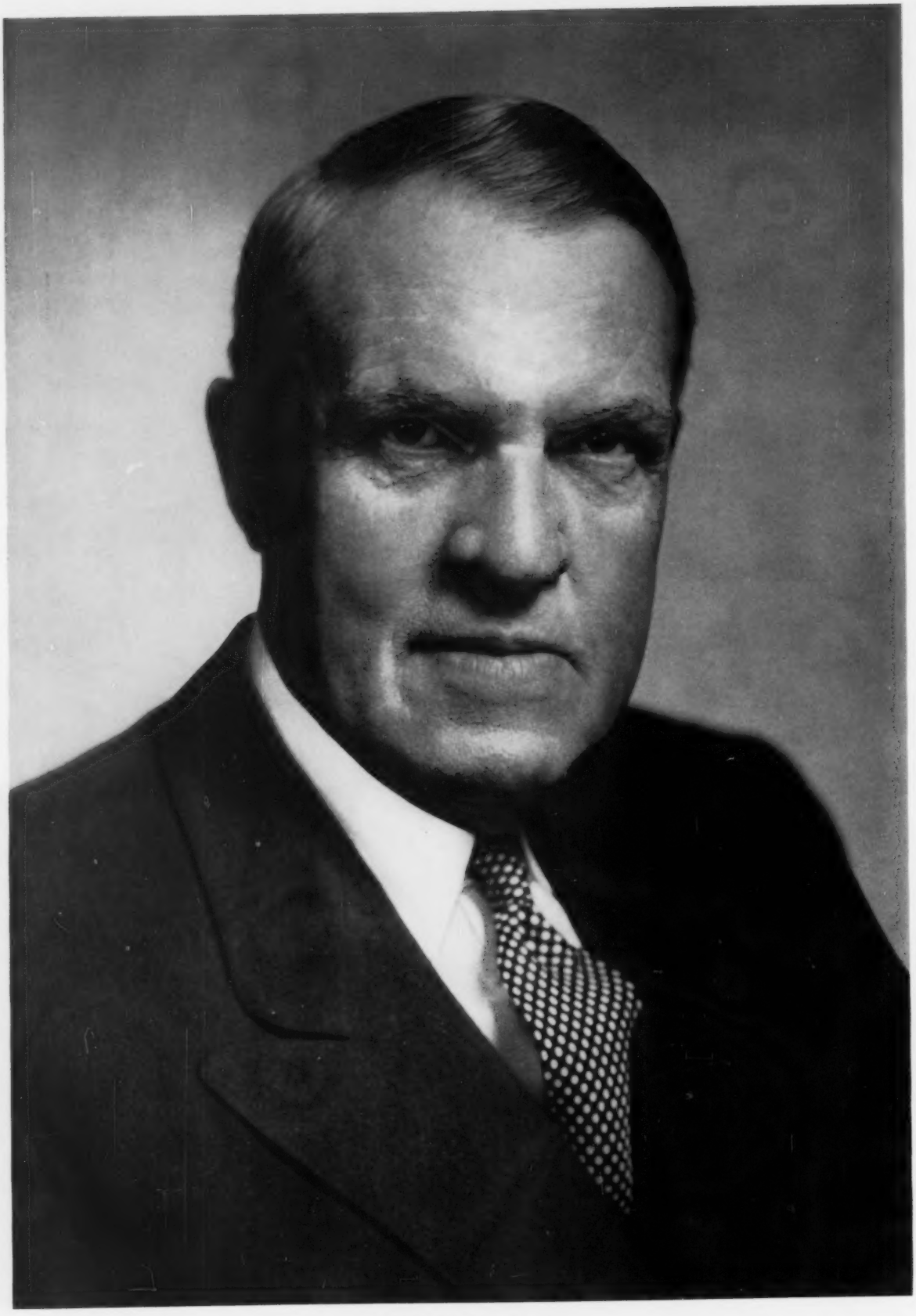


CLYDE EVARTS WEED

Clyde Evarts Weed

CHAIRMAN OF THE BOARD

THE ANACONDA COMPANY

A Biography

CLYDE EVARTS WEED, chairman of the board of The Anaconda Company, is recognized as one of the world's outstanding mining executives. For more than forty years, he has given freely of his technical and administrative abilities to one of the most important aspects of our economy, thereby contributing substantially to the national stability and welfare. His personality, energy, and knowledge have inspired many; his achievements have enabled his fellow men to live richer, more satisfying lives.

Clyde was born August 8, 1890, in Moorestown, Missauke County, Michigan, the son of Herbert Moores and Emma (Van Aiken) Weed. After completing the courses at grade schools in Petrieville and Bellevue, Michigan, and at Bellevue High School, he went to Michigan Agricultural College, now Michigan State University. At the end of the freshman year Clyde took a job as a surveyor's helper with Burt Portland Cement Company in Bellevue in the building of a plant. After a year with the surveying crew, he matriculated at Michigan College of Mining and Technology in Houghton, and was graduated in 1911 with B.S. and E.M. degrees.

Soon after graduation, Clyde began his career in the mineral industry by taking a job as a miner in Calumet & Hecla's Superior mine in Houghton. Two years later, he became mine superintendent for Victoria Copper Mining Company in Ontonagon County, Michigan. This move was followed by a succession of jobs within the industry: 1915-1917, superintendent, Lake Copper Company, Ontonagon County, Michigan; 1917-1920, manager, Hancock Consolidated Copper Company, Houghton County, Michigan; 1921-1923, foreman, Live Oak Division, Inspiration Consolidated Copper Company, Miami, Arizona; 1924-1929, assistant manager of Inspiration's operations in Miami, Arizona; 1930-1935, general manager, Cananea Consolidated Copper Company, Cananea, Sonora, Mexico; 1935-1938, president and general manager of Cananea in Mexico; 1938-1942, general manager of mines, The Anaconda Company; 1942-1952, vice president in charge of Anaconda's mining operations; 1952-1956, vice president in charge of all Anaconda operations; 1956 to April 24, 1958, president of The Anaconda Company; April 24, 1958, to date, chairman of the board of The Anaconda Company.

Mr. Weed is also chairman of the board and a director of Andes Copper Mining Company; Chile Copper Company; Chile Exploration Company. He is president and a director of Butte, Anaconda and Pacific Railway Company; Greene Cananea Copper Company; International Smelting and Refining Company. He is a director of The American Brass Company; Anaconda Aluminum Company; Anaconda American Brass Limited; Anaconda Sales Company; Anaconda Wire and Cable Company; Chile Steamship Company Incorporated; Potrerillos Railway Company; Guaranty Trust Company of New York.

He is president and a director of Copper Institute; vice president of U. S. Copper Association; a director of American Mining Congress; a regular member of the National Industrial Conference Board; and a member of American Institute of Mining, Metallurgical, and Petroleum Engineers.

Mr. Weed has taken an active interest in United Cerebral Palsy. He served as co-chairman of its annual National Fund Appeal in 1957, and is the chairman of the 1958 fund drive.

His clubs include Tau Beta Pi Fraternity; India House, University, River, and Mining in New York City; Sleepy Hollow Country in Scarborough, New York; Clove Valley Rod and Gun Club, La Grangeville, New York; Butte Country in Butte, Montana; and Cat Key in Cat Kay, Bahamas.

In 1946, Mr. Weed was honored by Michigan College of Mining and Technology with the award of the honorary degree of Doctor of Engineering. In 1951, he was awarded the William Lawrence Saunders Medal by the American Institute of Mining, Metallurgical, and Petroleum Engineers; in 1955, he received the Michigan State University Centennial Award; in March, 1957, the Government of Chile bestowed on him the "Order of Merit General Bernardo O'Higgins," in the rank of Knight Commander; in June, 1957, he was honored with the Award for Distinguished Service by the Michigan State University Alumni Club of Washington, D. C.

Clyde Evarts Weed married Mary Morrison in 1917. They had one son, Herbert Morrison Weed. Following the death of his first wife, Mr. Weed married Albertine Milan on June 17, 1930, in Chicago. The family home is at River House, 435 East 52nd Street, New York City.

When time and opportunity permit, Clyde finds relaxation in the great outdoors—hunting, fishing, and playing golf with his friends.

The guiding of THE EXPLOSIVES ENGINEER by the head, heart, and hand of Joseph I. Horty concludes with this issue. Joe Horty is retiring after a career with Hercules Powder Company that stretches back more than forty-two years – all in the industrial explosives area of the company's business.

Right from the start of his work with commercial explosives, Joe was out in the field, selling and servicing, getting to know the people who use dynamite: learning their needs, their problems, learning what would help them most.

When in 1943 Joe was selected as editor of THE EXPLOSIVES ENGINEER, he had accumulated a wealth of experience in explosives technology. More important, he was not an unknown editor writing for an unknown group of readers; he was a practical explosives man, well known to many of his readers, editing a publication for people he knew and whose needs he knew. From this experience was distilled a distinct, readable editorial style that can come only from thorough knowledge. The acceptance accorded THE EXPLOSIVES ENGINEER during the fifteen years of Joe's editorship attests that his understanding of explosives as a force for the benefit of mankind was used to excellent advantage.

Without doubt many of you who read THE EXPLOSIVES ENGINEER will join with Joe Horty's associates in Hercules in wishing him the long and happy period of retirement that he has so well earned.

THE EXPLOSIVES ENGINEER ★ DEVOTED TO INCREASING EFFICIENCY AND SAFETY IN THE MINING, QUARRYING, AND CONSTRUCTION INDUSTRIES

Editorial

A recent report of the Institute of Makers of Explosives of the injuries to children from playing or tinkering with blasting caps makes disheartening reading. These statistics would make disheartening reading if only one boy or girl were injured. We know that the number of blasting cap accidents to children when compared with the consumption of explosives and with the total number of children makes a somewhat better showing.

Children injured per million pounds of explosives produced have declined for a number of years. So, too, the number injured per million children in the age group under consideration, up to the age of 16, has declined. These ratios have declined by virtue of the steady increase in explosives consumption and the sharp increase in the population in the lower age groups. There is small consolation in these relative decreases, even though they do reflect the efforts made to reduce the number of children hurt.

Statistics to the average person are dull and uninteresting facts and figures. But if you read the detailed story behind each accident, the statistics in the report take on serious meaning. Then, behind the numbers, you can visualize how many children will never play baseball because blasting caps mangled hands or blew off fingers. Some youngsters won't kick footballs because caps have shattered ankles. Also, behind the statistics, you can reflect on how many boys and girls will have to learn to read with their fingers because blasting caps blinded them.

The statistics are children—children who before their accidents were healthy, adventurous boys and girls—normal American youngsters with a zest for living.

For many years the Institute of Makers of Explosives has directed a never-ending campaign to prevent these pitiful accidents to children. It designed and distributed the materials to carry the warnings to the children of the nation and to the users of blasting caps. In these efforts to warn the children, the Institute has had the wholehearted assistance of many agencies working with our youth. The schools and school teachers, the Boy Scouts and Girl Scouts, the Future Farmers and 4-H Clubs, the police chiefs, sheriffs, and firemen, the newspapers, radio, and television stations, and many others have given freely of their time, their energy, and their facilities to carry this warning. Indeed, it can be said that without the assistance of the people who work with boys and girls, and the communications media of our country, no significant progress could have been made in the reduction of injuries.

Similarly, the Institute has always had splendid cooperation from mining, quarrying, and contracting companies who use large quantities of blasting caps. Invariably these companies have cautioned their employes to keep their blasting caps out of the way of children, with the result that, considering the large number of caps used by these heavy consumers, few accidents have been traced to them.

Despite these efforts, carried out over the years with ever-mounting vigor, children continue to be injured from playing with blasting caps. To meet this situation, we should dedicate ourselves anew to the task of preventing these accidents. We must seize every opportunity to carry this warning to the children, and win the cooperation of everyone who uses explosives.

Portable Plant Crushes Limestone In Six Kansas Quarries

An unusual cycle of operations averages a daily production of 1,600 to 2,000 tons of prepared stone to supply a wide variety of customers

LEWIS NORDYKE*

THERE used to be an old saying to the effect that when a settler in Kansas was droughted out, or grasshoppered out, all he had to do to head for a new location was load his wife and kids in the wagon and call the dog. It is about as simple as that for John Stark to move his stone-crushing plant. John blasts, excavates, and crushes limestone in his six quarries in southeastern Kansas and converts it into a number of useful products.

*P. O. Box 8075
Amarillo, Texas

Stark, a veteran in the crushed-stone business, operates in Crawford, Labette, and Cherokee Counties, using a portable plant. Rather than maintain an expensive permanent installation at each of his quarries, he has one string of mechanical equipment that is

STARK'S PORTABLE PLANT: This is the portable plant in which John Stark produces various sizes of crushed and washed limestone at his six quarry properties in southeastern Kansas. The plant is moved from quarry to quarry as the demand for the finished products dictates. Although some of the quarries are 60 miles apart, the details of dismantling, loading, moving, and reassembling the plant equipment for work are accomplished in from two to six days, depending on the distance of the move.

STRIPPING OVERBURDEN: Before a round of blast holes is drilled in the Stark quarries, an overburden of clayey soil averaging 7 ft. in depth is stripped from the limestone deposit with a Caterpillar D-7 bulldozer.

moved from pit to pit as business requires.

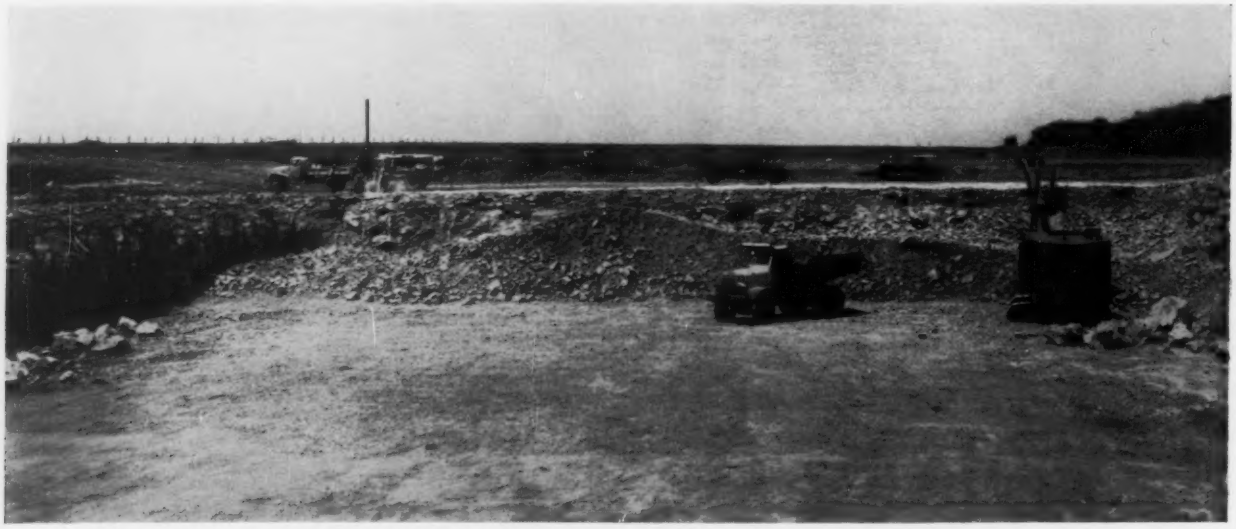
Stark's limestone products are used in highway construction, in ready-mix concrete plants, for agricultural purposes, for filter rock, and chips. Any one of five of his six quarries has a sufficient deposit of stone to serve his trade. But, the cost of hauling the finished products over a wide territory makes the use of a single pit an economic impossibility. So, he hauls equipment rather than rock.

Here is an example of how this portable business works: Stark sets up at the Girard Quarry in Crawford County. He blasts the rock, crushes it, and stockpiles enough of each size to last several months. Then he moves to another quarry and repeats this procedure. He continues the program until all six of his pits are stockpiled, after which he starts the work cycle all over again. Usually, each stockpiled quarry is open two to six days a week with a man at hand to weigh out the rock for customers. In this way, the hauls to users are short.

Anyone who needs lime or crushed limestone is a potential customer for Stark. His operations produce from 1,600 to 2,000 tons of material each day.

Operations in Southeastern Kansas

The counties in which Stark does business are in the southeastern corner of the state, bordering on Missouri and Oklahoma. This section is apart from



TYPICAL QUARRY FACE: The rock formation is principally Fort Scott limestone that averages a height of 16 ft. The clean, uncluttered quarry working faces and floors contribute to uninterrupted operating procedures and safe working conditions.

DRILLING BLAST HOLES: A two-man crew with a Joy 400 unit drills 3½-in.-diameter blast holes 16 ft. deep in staggered rows. The rows are 7 ft. apart. The usual drill round in Stark quarries comprises four to five rows, each with about seven holes per row.

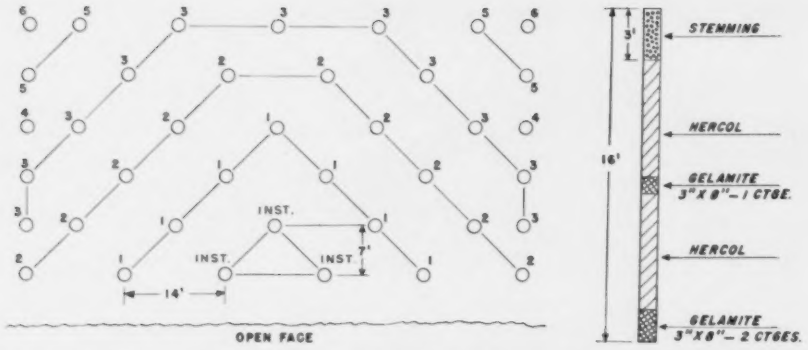
the state's noted prairie region. It is a wooded corner near the edge of the Missouri Ozarks. Aside from a few ridges and streams, such as Lightning Creek, the terrain is generally level, and scattered over a wide area are some mighty mounds, the tailings of lead and zinc mines, and the piled-up overburden from coal strip mines. This has long been an active mining area. Coal production built such wide-streeted, substantial towns as Pittsburg, Kansas, the largest community in the immediate vicinity. Some great mining companies, such as Sinclair Coal, had their start in the long ago at Pittsburg. Not far away is Joplin, Missouri, the center of the mining industry for ages. Between Pittsburg and Joplin some especially large coal-stripping operations are located.

Incidentally, the tailings at some of the mines in the area make the hard-surfacing material business extremely competitive. Excellent chat is available in the old tailings, and it is cheap. But, the cost of hauling is the important factor. This is another reason why Stark worked out a portable operation: he had to make it cheaper for his customers to haul rock comparatively short distances than to have to haul mine tailings greater distances.

Topography

The general area has an elevation ranging from 900 to 1,000 ft. above sea level. The annual rainfall is from 35 to 45 in. Weather is only a minor factor in the operation of the quarries —a heavy rain or storm may close down the work for a short time. But, weather is a factor of major importance in the agricultural well-being of the region. This is good farming country. It produces wheat, corn, oats,

LOADING EXPLOSIVES: After the drilling is completed, each hole is inspected for water and pockets. Then the charges of Gelamite 1 and Hercol free-flowing powder are loaded, using a loading ratio of 0.85 to 0.95 lb. per cu. yd. of rock in place.



LAYOUT OF A BLAST: The larger drawing shows the location of the drill holes in a primary blast in a Stark quarry. The numbers alongside the holes indicate the order of firing. The smaller drawing, at right, shows how each hole is loaded with charges of Gelamite 1 and Hercol powder, and the stemming at the top.

EXPLOSIVES IN ACTION: Primary blasts produce good initial fragmentation of the limestone because of the relatively heavy charge of explosives in each hole. Experience has demonstrated that this method eliminates secondary blasting and minimizes wear and tear on equipment.

soybeans, sorghums, other field crops, and a sizable number of beef cattle. It also has a good deal of poultry production.

The soil is of the type that needs an occasional shot of lime. In many cases the application of lime has brought increased production and helped to make the farmers happy.

It was the lime business that attracted John Stark to the area. The hard limestone available is of high calcium content and is excellent for the soil. It exceeds the 80 per cent calcium carbonate required by the United States Department of Agriculture for soil-treating lime. In cases in which Federal agencies participate financially in the application of lime, the Government tests the lime at intervals to make sure it is of the right content. In his field laboratory, housed in a large auto trailer, Stark makes continual tests of gradation of all his products.

Stark's stone products exceed the standards for highway and concrete material. The deposits at his properties are principally Fort Scott limestone. The beds tip upward to the south and east and are covered with from 2 to 7 ft. of clayey soil. There are some thin seams of shale in the stone.

Expanded Operations

As Stark developed his agricultural lime business, he discovered sufficient limestone to expand into other products. When he located in Kansas in 1945, he intended to operate there for about three years. But, the demand for road- and concrete-materials changed his mind. Variations in farming conditions in recent years have temporarily decreased the use of lime. However, the demand for other products of his quarries has increased, and major production is now keyed to highway base material and concrete rock.

"All indications point to an increase in road building and we are prepared for it," Stark said. "We realize a big saving from our methods because we can work all the quarries with a single plant. And, we could not operate economically without using explosives properly. We have done a lot of experimenting to get the results we want and, at the same time, to keep down the cost of blasting. We are well

AFTER A BLAST: Power shovel operators find easy digging in the muck piles after blasts. They load the broken stone into 7-cu. yd. end-dump Euclid trucks for deliveries to the crushing plant.

pleased with the methods developed in our properties."

Drilling and Blasting

Although the several quarries vary as to size, overburden, water seepage, and other factors, the blasting techniques are about the same. The Girard Quarry is a good example. The pit is about 1,000 ft. square. The overburden averages about 7 ft. deep. This is stripped with a Caterpillar D-7 dozer. Nearly all of the overburden is pushed into areas that have been quarried and, as a result, the terrain is not marred by mountains of waste.

The two-man drilling crew works a full shift every day, keeping well ahead of the shovels. The 3½-in.-diameter blast holes are drilled in staggered rows, with each hole 16 ft., which in this quarry is the thickness of the limestone. The rows are 7 ft. apart. The first row is drilled 7 ft. from the toe of the face. Four to five rows, each with an average of seven holes per row, comprise the usual round.

The drilling is done with a Joy 400 drill mounted on a Ford tractor. A Gardner-Denver compressor of 365-c.f.m. capacity powered with a Caterpillar D-13000 engine produces the air to power the drill and to blow out the cuttings. The compressor trails behind a Chevrolet truck. Timken and Ingersoll rock bits, size 3½ in., are used. The drill rig takes 12-ft., 1¼-in. Gardner-Denver hollow steel. One 6-ft. length of steel is added on top to finish the hole to the right depth. The rig drills at the rate of two holes an hour.

Loading the Explosives

When the drilling is finished, the holes are inspected to the bottom by a reflector mirror (flashlight on cloudy days). They are loaded on a ratio of 0.85 to 0.95 lb. of explosives to each cubic yard of material in place. This is fairly heavy loading, but Stark has learned that effective fragmentation in his blasts saves wear and tear on equipment.

Two 3 by 8-in. cartridges of Gelamite® 1 are placed in the bottom of each hole, where the breaking is to a limestone seam. When the break is to shale, the Gelamite is not used.

In a dry hole, Hercol,* a free-flowing bag powder, is poured in until the hole is half filled. Then, in the middle, on top of the first batch of Hercol, a 3 by 8-in. cartridge of Gelamite 1 is placed as a priming charge. The remainder of the hole is filled with Hercol to within 3 ft. of the collar, after which it is stemmed with drill cuttings. A short-period delay electric blasting cap with 12-ft. leg wires is placed in the primer cartridge. When all the holes are loaded, the cap wires are hooked up in a series. A round of

*Hercules Trademark

STOCKPILES OF FINISHED PRODUCTS: After the limestone has been crushed and washed in the plant, the finished products are stockpiled at each quarry property. This method assures prompt distribution to a variety of users.

up to 50 holes is fired in one series. If there are more than 50 holes, the cap wires are hooked up in a series-parallel connection. Blasts are fired with a 410-volt blasting machine.

This method of primary blasting produces excellent results and there is no secondary blasting.

Four men load a round of 30 to 50 holes with explosives in an hour. This loading procedure usually starts at 7 o'clock in the morning and the blast is fired at 8 o'clock. This eliminates any possibility of having loaded holes left overnight, or for long periods. Stark's blasting crew adheres strictly to accepted safety measures.

In the event of a pocket, or chamber, in a blast hole, the charges of Hercol are placed in 23G containers to build up past the pocket.

In some of the quarries there is quite a bit of water seepage, and wet holes are the result. These wet holes are loaded in the same manner as the dry ones except that the Hercol powder is placed in containers. If a hole is wet only at the bottom, the containers are used to build past the wet section, and the remainder of the hole is loaded as if it were dry.

Plant Operations

The blasting produces an easily worked muck pile. Power shovels recover the broken material. Stark has four shovels for this work and for loading from stockpiles. They are one 1-cu. yd. Koehring 405, one ¾-cu. yd. Northwest 25, one ¾-cu. yd. Bucyrus-Erie 20B, and one ¾-cu. yd. Bucyrus-Erie 22B.

The Koehring shovel is used chiefly in the quarry. It loads into Euclid trucks, powered by General Motors diesel engines. Each end-dump truck has a capacity of 7 cu. yd. Six of the trucks are used in this operation. The "Eukes" also haul from crusher to stockpiles.

The haul to the crushing plant is about a ¼-mile. The plant is equipped with Cedar Rapids primary and secondary crushers. The trucks dump into a 3 by 12-ft. apron feeder, which empties into a 22 by 36-in. jaw crusher. This primary crushing reduces the limestone to a 7-in. maximum. From the crushers the material is conveyed to a Kolman 4 by 8-ft. scalping screen for the removal of shale and other waste.

SUPERINTENDENT OF OPERATIONS: George Nettels is superintendent of operations in the John Stark organization. He directs the activities that average a production of 1,600 to 2,000 tons of prepared limestone each working day.

From there the rock goes through conventional crushing plant equipment, and the various products are eventually conveyed to loading hoppers, and then hauled to the stockpiles. As many as four products come from the crushing plant at the same time.

The agricultural lime is virtually pulverized—90 per cent passing through a No. 8 screen and a 25 per cent minimum passing through a 100 screen. The highway material ranges from 1½ in. to fines. The concrete stone is reduced from 1½ in. to No. 8 screen. A comparatively small amount of larger rock is stockpiled for use in drainage work. The chips reduced from ½ in. to No. 4 screen are used primarily for private roadways and drives.

The crushing equipment is in several sections. Most of it is powered by electricity. The power is made by a portable Kato generator of 125-KVA capacity that is pulled by a GM 671 diesel engine.

(Continued on page 92)

Driving Raises By the Long-Hole Method

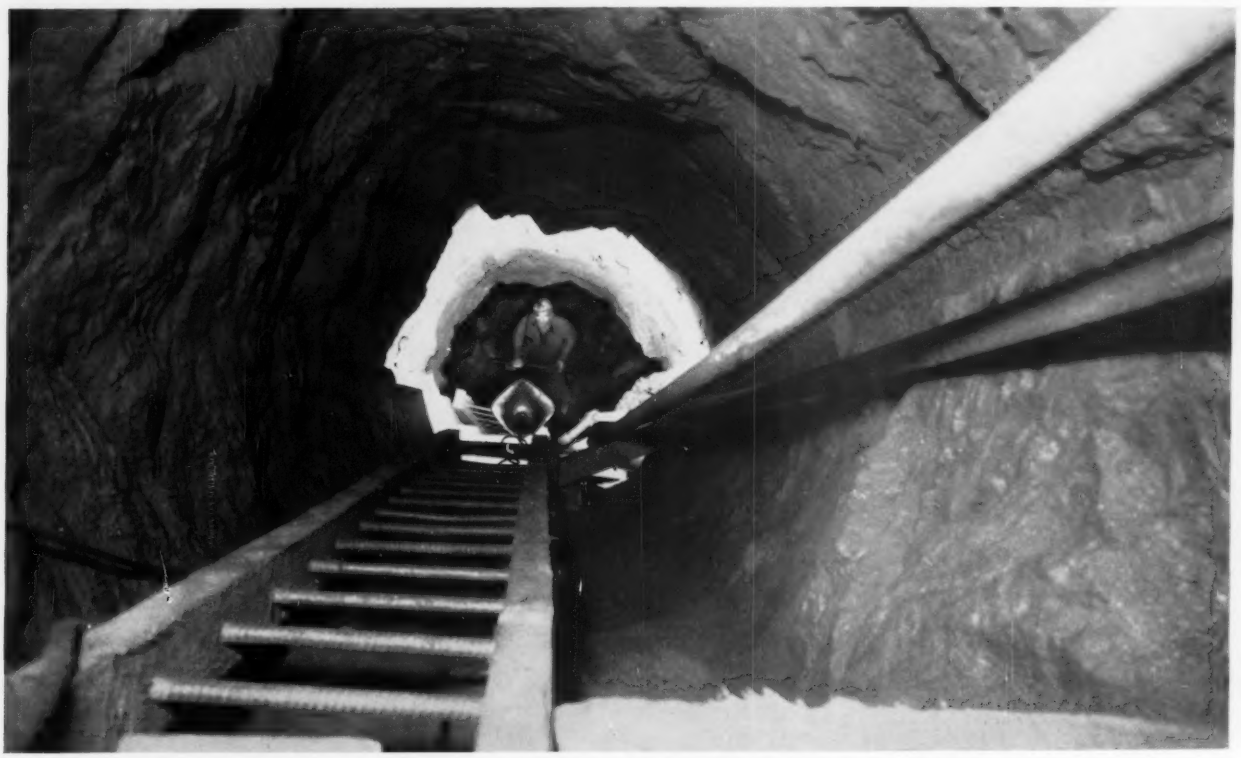
Experiments in Inland Steel's Greenwood Mine on the Marquette Iron Range in Michigan show favorable costs per foot of raise and safer working conditions

A. P. GUSTITIS*

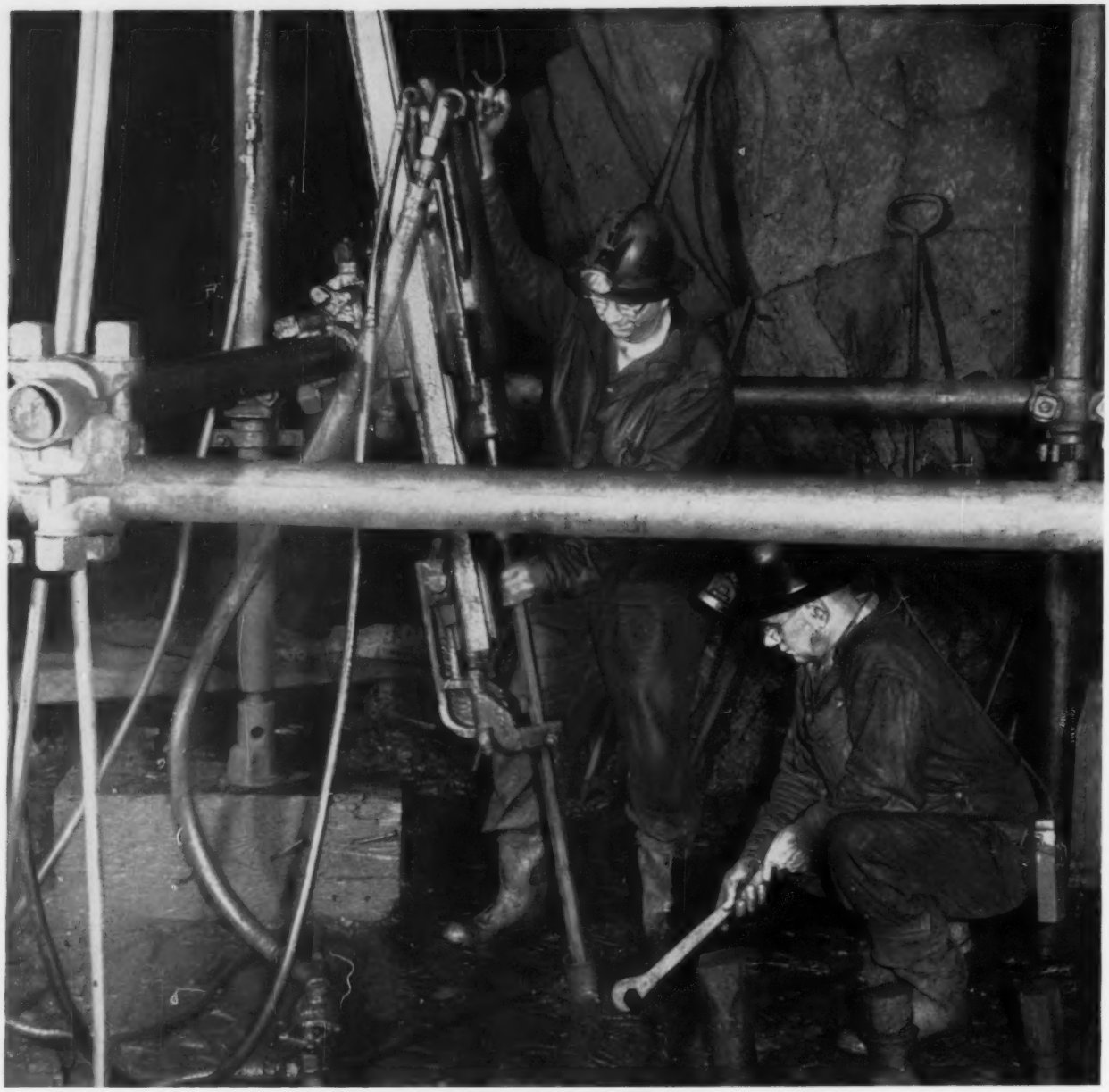
THE Greenwood Mine of Inland Steel Company is located at Ishpeming, Michigan, on the Marquette Iron Range. The ore in the mine workings is of a specular hematite and magnetite. It is fairly hard and abrasive, but fractures well when blasted. Also, the ore is sufficiently hard to retain its shape without cribbing for raises.

*Hercules Powder Company
Duluth, Minnesota

R. C. Annear, superintendent, and R. J. Lacke, the mining engineer at Greenwood Mine, began planning to speed up the work details in driving raises, with safety in mind. They decided to first drill a 3-in.-diameter pilot hole up the center of a raise. The primary reason for this hole was to provide a means for hoisting all staging and drilling materials to the working face, thereby eliminating the necessity for the miners doing so by hand



FORTY-FOOT RAISE: The completion of this 40-ft. raise, the first one drilled and blasted by the long-hole method in the Greenwood Mine of Inland Steel Company at Ishpeming, Michigan, was accomplished in July, 1957. It is a single-compartment, uncribbed raise. One important feature of the long-hole method is that no miner has to work in a raise until it has been completed.



CAREFUL DRILLING: A closeup of long-hole drilling operations in a raise in the Greenwood Mine. Extreme care is taken in hole alignment and in repeated checkings at the start to keep the holes as nearly parallel as possible.

hoisting. A tugger was mounted above the raise with a cable lowered through the pilot hole. This hole was also utilized to good advantage as the relief hole in the burn-cut round.

The pattern decided for the first raise was to drill a burn-cut with the outside holes on a perimeter of a 4-ft. circle. A 4½-in. percussion drill was set up on the sublevel at the bottom of the proposed raise, and eleven 3-in. holes were drilled as illustrated in Figure 1. A relief hole was in the center with four holes around it. Two holes were at 9 in. and two holes at 12 in. from the center of the raise. The remaining six holes were 12 in. from the burn-cut holes. Extreme care was taken in the alignment of the holes and in repeated checking in starting to drill the holes to keep them as nearly parallel as possible.

When the drilling was completed, the pattern was not the same as the starting pattern, but none of the holes were more than 12 in. away from the intended break-through. This could be contributed to the use of three different types of bits in drilling the holes. However, it did not affect the raise in any way. The three different bit types were used for experimental purposes to determine which would drill a hole as nearly parallel as possible to the center line of the raise. The three types of bits were a chisel point, an X-bit, and a cross bit. Results showed that the cross bit drilled the straightest hole in this type of ore.

Safer Working Conditions

The completion of a raise by the long-hole method was accomplished at Greenwood Mine in July, 1957. It was a 40-ft., single-compartment, uncribbed raise. An identical raise of 27 ft. is being drilled at this time (see Figures 2 and 3). One important feature of a raise like the one referred to above is that it can be driven without a miner having to work in the raise until after it has been completed.

Prior to the raising, floor pillars were being mined by long-hole drilling. This was the forerunner to raising by this method. In one instance, a group of holes was drilled in a pillar that was narrow in width and thick in depth. To eliminate the danger of sticking this pillar by shooting it in one blast, it was decided to load a charge of explosives in the bottoms of the holes to break small portions of the ore to a stope below. By doing this repeatedly, an irregular hole was broken through. Enough information was developed to determine that the miners could blast small

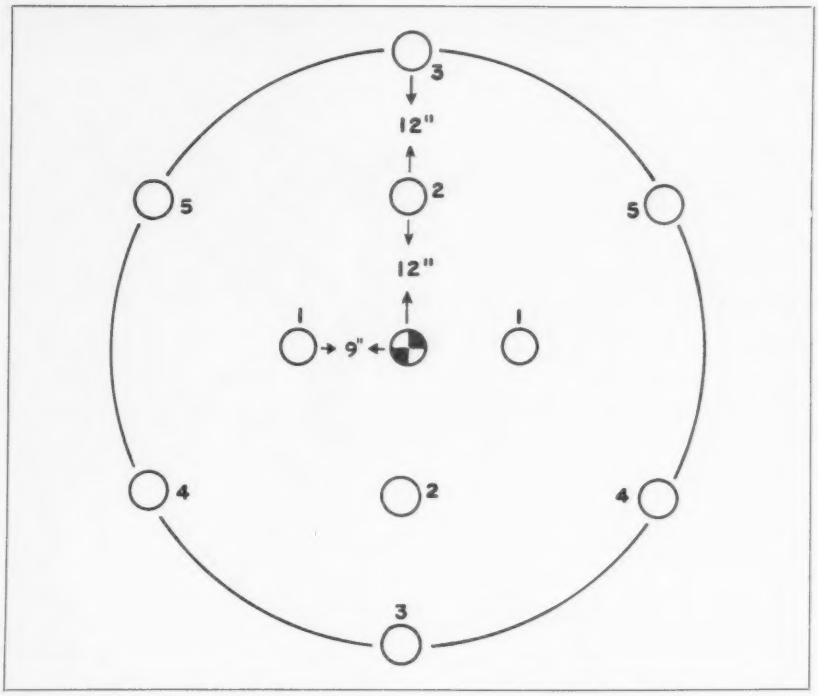


FIGURE 1: The drill pattern for the first raise included a relief hole in the center with four holes around it, and six outside holes on a perimeter of a 4-ft. circle. Numbers alongside the holes indicate the order of firing the explosives charges in the blast.

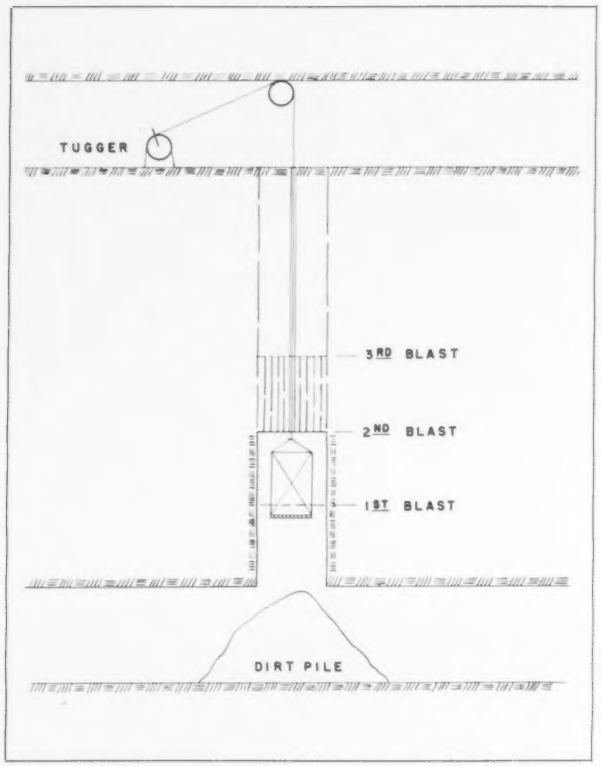


FIGURE 2: This drawing shows some of the details involved in the use of a single 3-in.-diameter long hole between levels to serve as the center line for the raise and a "buster hole" for the blast.

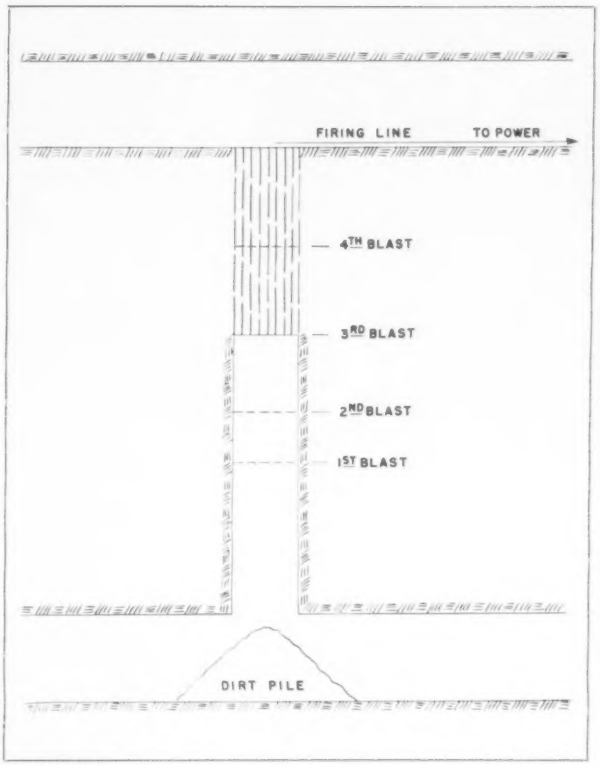


FIGURE 3: The above sketch outlines the method adopted for using a long-hole machine to drill out a raise completely from either top or bottom. The holes are blasted from the collars.

MINE HEADFRAME: This is the headframe at the Greenwood Mine of Inland Steel Company located at Ishpeming, Michigan, on the Marquette Iron Range.

portions of a hole and not damage the remainder of the hole in this type of ore. It was also discovered that if a cross bit was used, the holes could be drilled almost parallel.

After a round of blast holes was drilled, all equipment was removed from the bottom and the explosives charges were loaded into the holes from the top of the proposed raise. Before loading the charges, the blast holes, having been drilled through, had to be plugged. This was done by fastening a sash cord to a wooden plug. The plug was covered with a small piece of paper to bind it, and a few inches of dirt was tamped on top, leaving the sash cord attached. The plug was raised and lowered until the bottom of the hole was determined. This procedure assured a good bottom and not much of it was lost.

Loading Explosives Charges

The holes were loaded with Gelamite® 1 in 2½ by 16-in. and 2 by 16-in. cartridges, primed with Hercules No Vent® Delay Electric Blasting Caps. Care was taken to keep the top of the dynamite charges in a plane normal to the centerline of the raise to maintain as clean a cut as possible. From 4 to 6 in. of stemming was used on top of the column of explosives in each hole.

After six blasts were fired, the raise was within 2 ft. of the upper level. The first and longest blast was 12 ft. This produced some overbreak around the raise. This overbreak was caused by propagation, thought to be due to a fracture in the ore that ran through the raise. The charges in the remaining blasts detonated in proper order. The second blast was reduced to 4 ft., the third to 7 ft., the fourth to 8 ft., and the fifth to 7 ft. All broke fairly clean to the tops of the columns of explosives. The remaining 2 ft. was drilled with small jackhammer holes and blasted between the 3-in. holes. The raise was then complete, as illustrated on page 77.

The explosives loading ratio was 25 lb. per 1 ft. of raise. In the overall cost per foot of raise, the long-hole method compared favorably with previous methods used.

In future, smaller diameter holes will be drilled to speed up drilling time and lower drilling costs. The explosives loading ratio per foot of raise will be reduced considerably because the ore in this raise was pulverized. This was caused by loading a large volume of powder in the large-diameter holes. The initial blasts will be reduced to keep the overbreak to a minimum and to minimize the chances of propagation, which could occur because of fractured ground around the raise. The length of the succeeding cuts will be increased as they are being advanced.

Advantages Summarized

The advantages claimed for this method of raising are:

(1) Elimination of the hazards involved in climbing up the raise, putting in staging, and drilling and loading a stage or platform.

(2) Elimination of the work of maintaining ventilation, pipes, and ladders in the raise during entire raising operation.

(3) It can be used where the hole-through point is inaccessible, or the holes can be drilled from the top before a drift is completed under the proposed raise.

(4) The finished raise is straight, and the starting point and hole-through points are known before blasting is done.

(5) Loading charges of explosives in the holes from the top is easier and faster.

(6) Provides greater safety for employes because they do not have to work in the raise until after it has been completed.

Blasting in a North Carolina Granite Quarry

An outline of the drilling and blasting procedures of Greystone Granite Quarries that increased production in a high working face near Henderson

W. M. MAY*

THE sprawling operations of Greystone Granite Quarries, Inc., four miles north of Henderson, in Vance County, North Carolina, are in the heart of a region long noted for the production of high-grade granite. The location of the quarry and crushing plant is a short distance south of the North Carolina-Virginia state line on U. S. Route 1.

Greystone's area of quarry activities was first opened in 1835 by Patrick Linehan to produce dimensional stone for use in constructing culverts and bridges, and as ballast on the right-of-way of the old Raleigh and Gaston Railroad, now a part of the Seaboard Airline system. Later, Seaboard operated the quarry to produce the thousands of tons of ballast stone needed for the proper maintenance of its many miles of roadbed.

*Hercules Powder Company
Birmingham, Alabama

THE BLAST AREA: A well-drill blast of fourteen 6-in.-diameter holes was made recently along the north side of Greystone's granite quarry near Henderson, North Carolina. The length of the blast area was 292 ft.; the height of the face was 167 to 172 ft.

LOADING EXPLOSIVES: The charge of explosives in each hole was deck-loaded with Kanex 2-H in the bottom and Tritex in the top. Kanite primer cartridges, with HC-1 boosters inserted in the wells, were interspersed through the entire column of explosives.

The quarry has been in almost constant operation since its opening in 1835. The more recent operators include Robert G. Lassiter, a contractor, who acquired the property in 1910 to produce crushed stone for his own requirements, and to supply the needs of other local contractors. In 1916, Raleigh Granite Company was formed to purchase the property and to install many improvements in the stone-producing equipment and plant machinery. The Raleigh company operated the quarry until 1937, when control was acquired by Southern Aggregates Corporation and an ambitious program of modernization was introduced. Nearly $1,000,000 was spent for new drilling, loading, and haulage units in the pit, and for a new crushing plant. When the new equipment was at work, Southern Aggregates had developed the most modern crushed stone operation in the South. During World War II, practically the entire production went into the national defense effort, much of it being used in the construc-

BLAST IN ACTION: When the 20,540 lb. of explosives loaded in the 14 blast holes was detonated, a mass of fractured granite was moved away from the quarry face in a uniform pattern.

EXCELLENT RESULTS: The excellent results from the blast are apparent in the low, sloping bank of rock on the quarry floor. It was estimated that the blast produced 79,261 tons of "easy-digging" granite.

tion of roads at Army cantonments in North Carolina.

Big Quarry Area

The present operator, Greystone Granite Quarries, Inc., took over the business on April 1, 1944, to produce various sizes of crushed stone for highways, railroad ballast, riprap, and screenings for asphalt plants. The quarry area is extremely large, with ample reserves of high-grade granite. There is room for expansion to the east and west. No more rock will be taken from the south wall of the quarry because a county road and the Seaboard's right-of-way are within a very short distance of that side of the property.

The geological formation in the quarry is a normal granite with the usual amounts of quartz, feldspar, and mica. This is characteristic of the granite deposit in that section of North Carolina. The quarry working face is 210 to 215 ft. at its highest point. This includes an overburden averaging 20 ft. At the present site of blasting operations, the overburden is composed of sapstone, disintegrated rock, and earth. It is easy to remove with a Northwest 2½-cu. yd. 80-D shovel. The excavated overburden is loaded into 13-cu. yd. Euclid diesel rear-dump trucks and hauled to the dumping area in a remote section of the property.

It is of interest to compare the drilling and blasting methods used today with the procedures used about 15 years ago:

Prior to 1942, the granite was quarried on three intermediate benches, each approximately 75 ft. high. A single row of 6-in.-diameter holes was drilled into the rock using Sanderson-Cyclone well drills. The usual practice was to blast a minimum of 20 holes at a time, the number depending upon the demand for the finished product.

BELT CONVEYOR: After the blasted granite has passed through the 48 by 60 Allis-Chalmers primary crusher, it is conveyed by an endless belt to the Symons-Nordberg cone crusher at the top of the quarry.

Blasting on the three benches did not prove satisfactory because of the difficulty in obtaining maximum efficiency from drilling and hauling equipment.

Operating Methods Changed

Greystone's engineers recommended the elimination of the three-bench system and the introduction of the blasting of the entire height of the quarry face at one time. Further efficiencies could be realized if the primary crusher was relocated at the quarry floor. This would provide a comparatively short haul in moving the blasted rock to the crusher. Stone from the primary crusher would then be conveyed by an endless belt to the secondary crushers at the top of the quarry. Relocating the primary crusher would also eliminate the need for a long, costly haul up the steeply inclined quarry ramp. The floor of the quarry was relatively level and a minimum of fill would be needed to establish a smooth, solid surface for the trucks.

A blast made recently in the entire height of face is typical of the new technique in use at Greystone. The area of this blast extended 292 ft. along the north side of the quarry. The working face varied from 167 to 172 ft. high. Fourteen holes, 6 in. in diameter, were drilled on 18 to 23-ft. centers. As the face was somewhat irregular, and it was hoped the blast would correct this condition, the burdens on the holes varied. Ten of the 14 holes had 20-ft. burdens at the toe, two holes had 15 ft., and two had burdens of 17 and 18 ft. In the east section, around holes 12, 13, and 14, there was about 40 ft. of toe that was left from a previous blast.

The 6-in. holes were drilled with a Sanderson-Cyclone churn drill and a Keystone 51 drill, each using 6-in. detachable Tungsten-Carbide bits. The bits performed exceptionally well in the tough granite, averaging 25 ft. of hole before they had to be pulled for sharpening. Compressed air for the drills and the bit sharpener was supplied by two Ingersoll-Rand compressors of 1,250-c.f.m. capacity and a 600-c.f.m. Jaeger portal compressor.

Loading Explosives Charges

The bottoms of the 14 holes were first loaded with 11,412 lb. of Kanex* 2-H, a non-nitroglycerin high explosive, packed in 5-in. by 30-lb. waterproof cans. As the charge of Kanex

*Hercules Trademark

approached the top of each hole, the type of explosives was changed to Tritex®, a nitro carbo nitrate blasting agent packed in water-resistant 5-in. by 25-lb. cartridges.

Kanite* primer cartridges, a nitro carbo nitrate primer, were loaded on top of the first two cartridges of Kanex 2-H placed in each hole. Similar primers were interspersed through the entire column of explosives. A Primacord†-sensitive HC-1 booster was inserted in the well of each primer cartridge. Until an HC-1 booster is placed in a Kanite primer at the bore hole, the primer assembly is not a high explosive.

Water was encountered in all holes, some with as much as 69 ft., and none with less than 35 ft. This water condition slowed the loading progress on several occasions because of the difficulty in lowering a cartridge through the water. At times, a cartridge became lodged on a slight projection in the bore hole. In some instances a stuck cartridge could not be dislodged and small, unloaded pockets remained in four of the holes. Loading the 14 holes with a total of 20,540 lb. of explosives required 12 hours' time.

As the loading of the Kanex 2-H charges progressed and built up to approximately the 102-ft. point, and had passed the water level in each hole, Tritex was loaded for the remaining footage. The last 15 ft. of each hole was stemmed with rock fines. An accurate log was maintained during the drilling activities and all the holes were deck-loaded to avoid blowouts at weak spots in the quarry face.

The reinforced plastic Primacord extending from each hole was connected to a main trunk line of Primacord which made a circuit of the holes. The Primacord trunk line was broken between holes and 17-millisecond Primacord connectors were inserted to give a delaying action to the blast. Detonation was accomplished with a Hercules® Electric Blasting Cap actuated by a Titan* Blaster, a condenser-discharge type of blasting machine. The delaying action of the 17-millisecond connectors helped to produce better fragmentation and to minimize vibrations. The Primacord trunk line was covered with rock screenings to reduce the noise.

*Hercules Trademark
†Reg. U. S. Pat. Off.
By The Ensign-Bickford Company

THE PLANT: The plant, with a capacity of 325 tons an hour, produces five sizes of crushed stone from 1½ in. down to screenings. Different sizes can be blended from storage bins to meet customers' specifications.

After Blasting

The results of the blast were excellent. Only a few boulders that would require reduction by secondary blasting were apparent and the pile of broken rock was uniformly out from the face without excessive throw. The engineers estimated that the blast produced 79,261 tons of rock, representing an explosives factor of 1 lb. to 3.9 tons of broken rock.

Boulders too large for economical handling by the shovels are reduced in size by secondary blasting. A Traveldrill, a remarkably useful piece of equipment for drilling holes for secondary blasting, drills a 1⅝-in.-diameter hole in each boulder, using a detachable Tungsten-Carbide bit. While no records are kept at this time of bit life in this type of drilling, previous records show wear to be satisfactory. Gelamite® 2, blasting caps, and Quarrycord* provide the punch to reduce the big ones to easily handled sizes.

*Reg. U. S. Pat. Off.
By The Ensign-Bickford Company

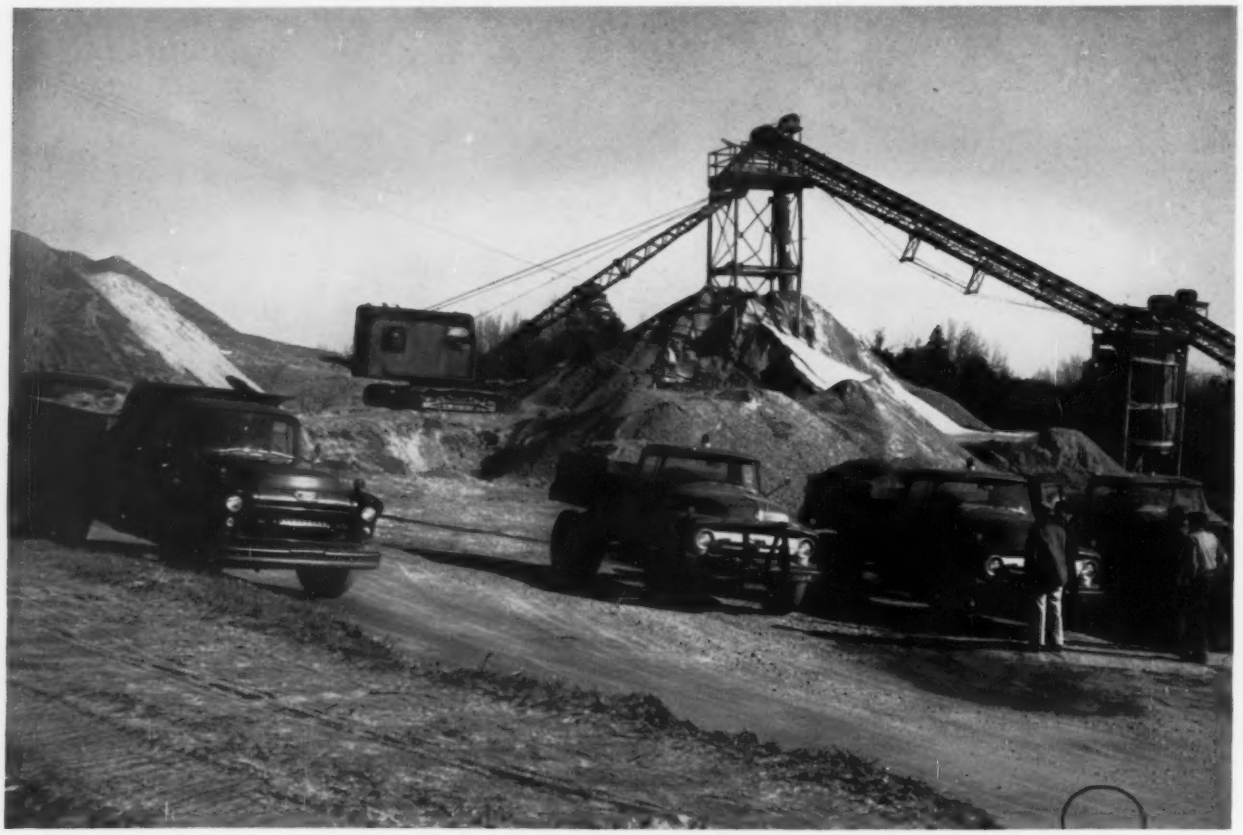
Equipment to keep the broken rock moving after a blast consists of two Bucyrus-Erie 50-B shovels with 2-cu. yd. dippers, and one Northwest 80-D shovel of 2½-cu. yd. capacity. Both shovels are mounted on tractors for ease of movement in the pit. Five trucks – three Macks, a Corbitt, and a White – each equipped with 10-cu. yd. Easton side-dump bodies, haul the rock to the primary crusher.

The primary crusher is a 48 by 60 Allis-Chalmers jaw-type unit. After the primary crushing, the rock is conveyed by an endless belt to the top of the quarry where a Symons-Nordberg cone crusher further reduces it. Ample tonnages of the various commercial sizes of crushed and washed stone are stockpiled and ready for immediate delivery. Short-haul deliveries are made direct from the stockpiles by truck. A spur line from the Seaboard Airline extends into the stockyard and long hauls are made in railroad cars.

The plant, with a capacity of 325 tons an hour, produces five sizes of crushed stone varying from 1½ to ⅜ in., also screenings. Different sizes of stone can be blended directly from the storage bins to produce the proper percentages to meet any specifications.

Greystone maintains a completely equipped shop. It is staffed with qualified mechanics who are capable of handling all the repairs and maintenance work needed on an operation of this size.

The progressive management of Greystone Granite Quarries, Inc., includes H. D. Hedrick, president, and C. H. Wolfe, secretary-treasurer. E. L. Brandtley is superintendent of all operations, and Flem Durham is the quarry foreman. Other activities of the Greystone organization are the Shelton Quarry, located on the Southern Railway between Reidsville, North Carolina, and Danville, Virginia, and the Buggs Island Quarry between Clarksville and South Boston, Virginia, which is served by the A. & D. Railroad.



STOCKPILES: Ample tonnages of commercial sizes of stone are maintained in stockpiles, ready for prompt deliveries. Trucks take care of short-haul deliveries, while longer hauls are made in railroad cars.

Safety Man

T. D. JANEWAY°

I like the way he says "hello,"
Not overdone, but just sincere.
Not one of us will ever know
Which life he's saved, this engineer.
He may be Bill, or Sam, or Jim,
But "Safety Man" we've christened him.

I often marvel at his skill,
The ease with which his eyes, long trained,
Can spot the things that maim or kill—
The misfired shot, the load unchained,
Defective tools, the clothes we wear,
Unshielded arcs, the cluttered stair.

He prays and works, he plans and strives;
From dawn to dark, it's just one fight
To teach us how to save our lives
And make us see that SAFETY'S right,
Just wishing he but had the power
To keep us safe each working hour.

Some day he'll make his last patrol
And cease his never-ending quest,
Then find he'd sensed life's proper goal
And now would tower above the rest—
For when one is a "Safety Man"
And works for love of fellow man,
He lives according to God's Plan.

°721 Edney Building
Chattanooga, Tenn.

The Role of Explosives In the German Attempt To Blow Up Remagen Bridge

Carefully developed plans of German Army engineers foiled by American troops' quick rush across the structure in the face of desperate efforts by the enemy to destroy it in World War II

DR. KEN HECHLER*

On March 7, 1945, a small detachment of American engineer, infantry, and tank troops came out of the woods on a high hill overlooking the Rhine River near the town of Remagen and observed the incredible profile of a bridge still standing across the river. They rushed across the bridge in the face of desperate German attempts to blow it up. This quick action by the American troops, one of history's most courageous feats, saved perhaps 5,000 casualties that might have occurred in an assault-crossing of the river barrier.

The German Army had made careful plans for blowing up the bridge at Remagen, and the quick work of the Americans in foiling the plans provides some interesting material in the use of explosives, both from a tactical and a technical standpoint. In the fast-moving events of World War II, some of the details have become shrouded in mystery, but interviews and records reveal the high points.

The bridge referred to was located at the sleepy little tourist town of Remagen, midway between Cologne and Koblenz, at the northernmost part of the Rhine gorge. It was a double-track railroad bridge with an overall length of 1,069 ft., with spans 278, 513, and 278 ft. long. It was constructed at the end of World War I and named the "Ludendorff Bridge" in honor of Germany's great wartime general. The floor of the bridge was about 50 ft. above the Rhine River at normal water level. The railroad tracks could be planked over for both foot and vehicular traffic.

When the Germans built the bridge, they carefully provided demolition chambers in the two stone piers so that, if necessary, it should have been easy to destroy the structure. But, when French troops occupied this section of the Rhineland after World War I, they methodically and humorlessly proceeded to fill up the demolition chambers in the piers with cement. Thus, they unwittingly performed a great service for their American allies, for the Germans had to devise a new and, as it turned out, less certain means of blowing up the bridge.

Germans Tested Demolition Methods at Remagen in 1938

On the eve of the outbreak of World War II in Europe, Germany's war machine was making very thorough preparations. The plans included not only mobilizing for the rape of Poland, but also for long-range defensive plans that they never anticipated having to use. However, as early as 1938, the Germans began conducting tests on how to blow up the bridge at Remagen if it ever became necessary. Since they could not use the cement-filled demolition chambers in the piers, they devised an electrically ignited series of 68-lb. charges of explosives packed in zinc-lined boxes which were placed below the railroad tracks on the floor of the bridge. The electric ignition switch for detonating the charges was located in a tunnel at the end of the bridge, and the ignition cable was enclosed in a steel pipe laid in the lower part of the bridge.

The plan called for an additional emergency charge of explosives which could be detonated with safety fuse

*c/o C. I. Whitten Transfer Co.
Huntington 17, West Virginia

THE BRIDGE AT REMAGEN: This bridge across the Rhine River, connecting the towns of Remagen on the west bank and Unkel on the east bank, was built by German Army engineers at the end of World War I. Chambers were prepared in the two stone piers in which charges of explosives could be placed if ever the structure had to be demolished.

INCOMPLETE DEMOLITION: When the Germans detonated explosives charges on the bridge, a cloud of smoke, dust, timbers, and girders was shot up into the air. Miraculously, the structure slowly descended upon its foundations. The Americans quickly rushed onto the bridge and crossed it in the face of continued attempts by the enemy to blow it up.

and blasting cap by hand, if, for any reason, the electric circuit failed. Of course, the plan had the disadvantage of being sensitive to jarring and shell-fire; the breaking of one contact in the circuit would break the entire circuit. However, there was a circuit tester available.

This demolition plan was devised to have the following effect: the bridge was not to fall directly down, but was to be destroyed at two dividing points so it would turn halfway on its axis and then drop to the south side. The explosives charges were stored carefully until such time as they would be needed. To help forestall sabotage, a dummy ignition cable was laid in the surface structure of the bridge where it could be found easily.

The plan for demolishing the bridge was thoroughly tested by the Germans during World War II activities and was considered to be in good working order. However, none of their officers or troops ever dreamed it would have to be put to use. Two thousand years earlier, Caesar had crossed the Rhine River on a specially constructed bridge close to Remagen. When he withdrew his forces, he successfully destroyed his bridge without difficulty. But, of course, the Germans were not interested in reviewing the musty pages of ancient history.

Germans Blast Antitank Ditch

As the American troops swept ashore at Normandy and irrupted across France, new defensive measures were taken by the Germans at all bridge structures along the Rhine. To prevent a sudden armored attack that would surprise the defenders of the Remagen Bridge, the German engineers prepared to blast an antitank ditch at the bridge approach. The ditch would be about 30 ft. wide and 12 ft. deep. This would delay the advance of enemy tanks and would give the bridge defenders enough time to set off the main demolition charges on the bridge itself.

The American forces kept pressing forward and penetrated the borders of Germany in September, 1944. At Remagen a company of German engineers continued to test the plan to demolish the bridge. Even in darkness or in bad weather they could be fully ready for demolition within 3½ hours.

Several days before the Americans reached Remagen, an incident downstream at Cologne directly affected the German demolition plans. At one of the Cologne bridges, a lucky American bomb landed on one of the demolition chambers, blew the structure sky-high, and left many German troops stranded on the west bank. Enraged, Hitler ordered that henceforth any officers who armed explosives on a bridge prior to the "last moment" would be court-martialed. This stern order created a psychology of delay. The decision to blow up a bridge is such a final and irrevocable one that, with this added incentive to wait, the Germans became much more conservative in their demolition plans.

Germans Prepare To Demolish Remagen Bridge

On the morning of March 7, Captain Willi Bratge, the German commander at Remagen, ordered Captain Friesenhahn and his engineers to prepare the bridge for demolition. About 11 o'clock, a German truck rumbled up to the bridge, presumably to deliver a fresh supply of explosives. To his consternation, the company commander of the German Engineers, Captain Karl Friesenhahn, discovered that he had been short-changed: the trucks had delivered only half the amount of explosives he had requested. Furthermore, he found he had been supplied with "Donerit," an industrial explosive of considerably weaker strength than the military explosives then in use. But, it was too late to correct the situation and Captain Friesenhahn had to make the best of what he had. With approximately 1,000 troops of varying kinds in the vicinity, the Germans should have been able to prepare and demolish the bridge even though the Americans were attacking with determined troops and General Sherman (35-ton) tanks.

At one o'clock in the afternoon, Captain Friesenhahn reported that the bridge was ready for demolition. By that time, the first American troops had broken through the outskirts of the town of Remagen and were already advancing into the town itself, the edge of which was about 2 miles from the bridge.

Meanwhile, a German artillery captain rushed to the bridge and asked that the demolition be delayed until

REPAIR WORK UNDER WAY: The first contingent of American engineers on the bridge cut every demolition wire in sight and dumped unexploded charges of explosives into the Rhine River. Meanwhile, our troops reached the far shore and kept the Germans at bay until a larger force could be brought up and establish a firm foothold.

he could get the men of his company with their guns across the bridge. But, at 2:35 p.m., as the Americans stormed to the approach of the bridge, Captain Friesenhahn ordered the antitank ditch to be blasted. The results were highly successful from the German standpoint; the Americans could not bring tanks onto the bridge for fully 8 hours thereafter.

Following some argument among the German commanders, it was decided to blow up the bridge shortly after 3 p.m. At 3:12 p.m., the electric circuit was tested and everything seemed to be in order. At 3:20 p.m., as the first American infantrymen were preparing to storm the bridge, Captain Friesenhahn personally attempted to operate the electric ignition switch that was to detonate the charges. He gasped as it failed to work. Quickly, one of his sergeants volunteered to crawl out and light the fuse and cap attached to the emergency charge, and he succeeded in doing so.

Soon after 3 p.m. on March 7, a tall Nebraskan named Lieutenant Karl Timmermann, company commander of the first infantry unit of the American 9th Armored Division, ordered his men to cross the bridge. The advance was interrupted by a terrific roar as the explosives on the bridge were fired, sending a cloud of smoke, dust, timbers, and girders into the air. The bridge seemed to have been lifted off its foundations.

"As you were," Lieutenant Timmermann ordered. "We can't cross the bridge now because it's just been blown." The men were stopped for a moment. But, miraculously, the bridge slowly descended upon its foundations. It was still standing! And then Lieutenant Timmermann, accompanied by his engineers, led the men across the bridge in the face of continued attempts by the Germans to blow it up.

The American Troops Storm the Bridge

The first American engineers who got onto the bridge—Lieutenant Hugh Mott, Sergeant Eugene Dorland, and Sergeant John Reynolds—frantically cut every demolition wire in sight and dumped many unexploded charges into the Rhine River. Sergeant Dorland hacked away at the cable- and switch-box and finally shot them apart with a rifle bullet. Meanwhile, the infantry troops reached the far shore and kept the Germans at bay until a larger force could gain a firm foothold.

JUST BEFORE THE END: Four hours after this picture was taken, the bridge across the Rhine at Remagen collapsed and fell into the river. A more detailed account of this crucial encounter with German Army engineers in World War II is presented in Dr. Ken Hechler's book, "The Bridge at Remagen."

Why the main charge of explosives on the bridge failed to detonate has been the subject of much investigation and debate. Various German soldiers and civilians came forward to claim they had sabotaged the cable. But, the evidence indicates they could scarcely have cut the main cable because it was hidden carefully underneath the planking of the bridge. Captain Friesenhahn states that as he was being brought back as a prisoner by our troops, he observed a gap in the steel pipe. This could have been caused by a lucky hit from an American shell. American artillery had been forbidden to fire at the bridge, but our tanks were throwing shells in that general direction and such a lucky hit is plausible.

After the capture of the bridge at Remagen, Hitler ordered the trial and execution of those officers "responsible" for allowing it to fall intact into American hands. Five officers were sentenced to death; four were summarily shot to death after being given 30 minutes to write to their families. The fifth officer, Captain Bratge, was not executed because the Americans had already taken him prisoner. Captain Bratge is now living in Germany where he teaches school in a small town of 250, still shuddering over his narrow escape. I am grateful to him for helping to supply some of the details of what happened on the German side of this episode. I am also grateful to the late Captain Friesenhahn; he was acquitted by the Hitler court-martial, but died last year in Germany.

Destiny Through the Hand of God

Perhaps it was the insufficient power of the German explosives that saved the Remagen Bridge, or a lucky hit by a tank shell, or a series of incidents that contributed to the delay. But the onrushing American infantrymen and engineers who seized the initiative on the spot probably had more to do with the Remagen victory than anything else. The very thorough Germans had a plan that had been carefully developed, tested, and retested, and which seemed infallible. But, destiny, through the hand of God, did not allow it to work.

PORTABLE PLANT CRUSHES LIMESTONE IN SIX KANSAS QUARRIES

(Continued from page 76)

Six Active Quarries

Stark has nine quarries, but at present only six of them are active. In addition to the Girard Quarry, the others—each named for the nearest town—are: Farlington, in Crawford County, 250 ft. wide and 1,000 ft. long, with an overburden of 2 to 3 ft.; Parsons, in Labette County, 500 ft. wide and 1,000 ft. long, with an overburden of about 7 ft; Sherman City, in Cherokee County, 350 ft. wide and 900 ft. long, with an overburden of 4 to 5 ft.; Mound Valley, in Labette County, 400 ft. wide and 1,000 ft. long, with an overburden of 4 to 5 ft.; Englevale, in Crawford County, 350 ft. wide and 800 ft. long, with an overburden of 5 ft.

The limestone seam in the several quarries varies from very thin at Parsons to an average of about 15 ft. The Parsons pit, the second one in that area, will be depleted in about three years. However, the other quarries have an almost unlimited reserve of limestone.

Stark and his engineers are constantly prospecting for new beds of stone. He leases the land and pays the owner a per-ton royalty. He hires contract truckers to deliver rock to his customers, which includes spreading the lime in the fields of farmers. However, if a contractor or farmer prefers hauling the material he buys from Stark, that is done.

Moving the Portable Plant

The blasting and crushing operations proceed at a quarry until there are sufficient stockpiles of all products to serve the trade for a reasonable time. When that quarry is stockpiled, the big move comes. The decision on where to move next is made on the basis of need in the vicinities of the various properties.

Although some of the quarries are as far as 60 miles apart, the dismantling, loading, moving, and resetting of plant equipment for work requires a remarkably short time—from two to six days, depending on the distance of the move. When Stark is ready to move, he obtains permission from state officials, who designate the route the equipment is to take.

Much of the machinery, even some sections of the crushing plant, rolls on its own wheels in the move, while other sections are jacked up and loaded on trucks. Actually, the trucks are backed under the jacked-up equipment. Dozers, shovels, and other machines are hauled on Fruehauf trailers.

It is seldom that all the equipment is readied, lined up, and moved in a single convoy, for that would jam a long section of highway. So some of it may be moved one day and the rest the next day. The moving and resetting is easy because it has been done often, every man knows his job, and there's a specific place for every piece of equipment. The reassembling of the plant requires very little time.

About the only equipment left at a freshly stockpiled quarry are the scales and loaders. Stark has five Hough Payloaders and one Shawnee loader mounted on an International tractor. At times, when there are large quantities of stone to be loaded from the stockpiles, one of the big shovels is transported to the job.

Operating Personnel

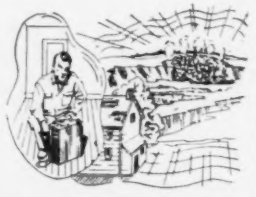
George Nettels is superintendent of operations in this progressive organization, assisted by Jack Scullen and George Vogel, foremen, and John O'Rourke, works engineer. Other employes include two drillers, one power shovel operator, one dozer operator, six truckers, two men on the jaw crusher, several plant men, one man on the scale, and one man in the field laboratory.

The work cycle is on a 10-hour-a-day shift, six days a week. The employes live in nearby towns and are home every night.

John Stark's first experience in quarrying rock was in Iowa and he remained there until 1933, when he moved to Minnesota. Later, he set up crushing equipment and produced highway stone in eastern Texas. He moved from there to Illinois, then into western Missouri, to Kentucky, and finally, to Girard, Kansas. He had in mind the production of agricultural lime for a few years and then to move on. But, the business in Kansas became permanent and has been expanded through the years to its present size.

Stark and his wife—an equal partner in the business—live in an attractive section of Girard, a town of about 2,500 population. He maintains an office downtown but is seldom there. He's usually at one of the quarries or out looking for more customers or new limestone deposits.

VIBRATION TROUBLES?



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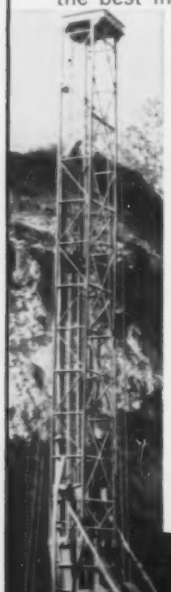

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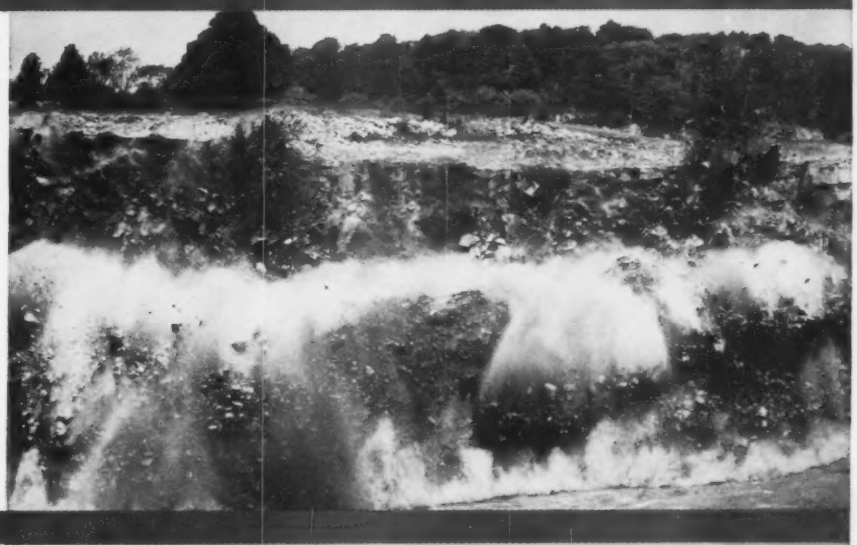

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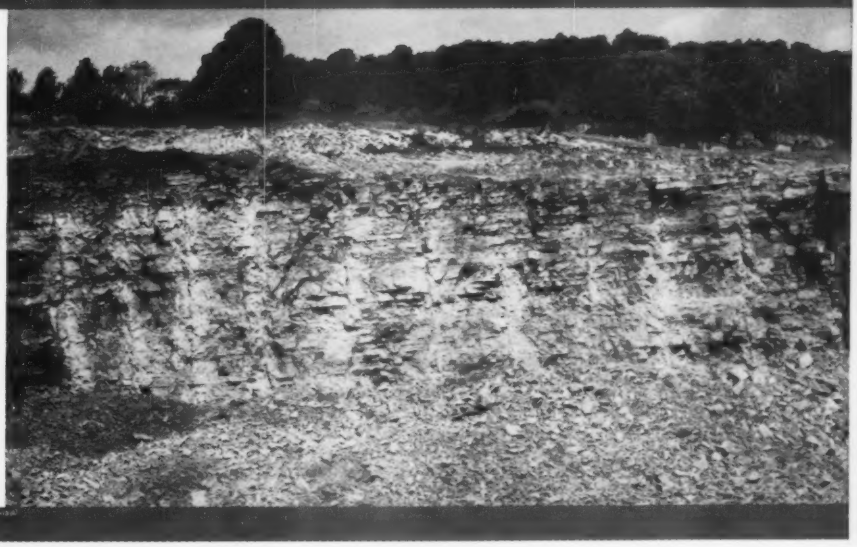

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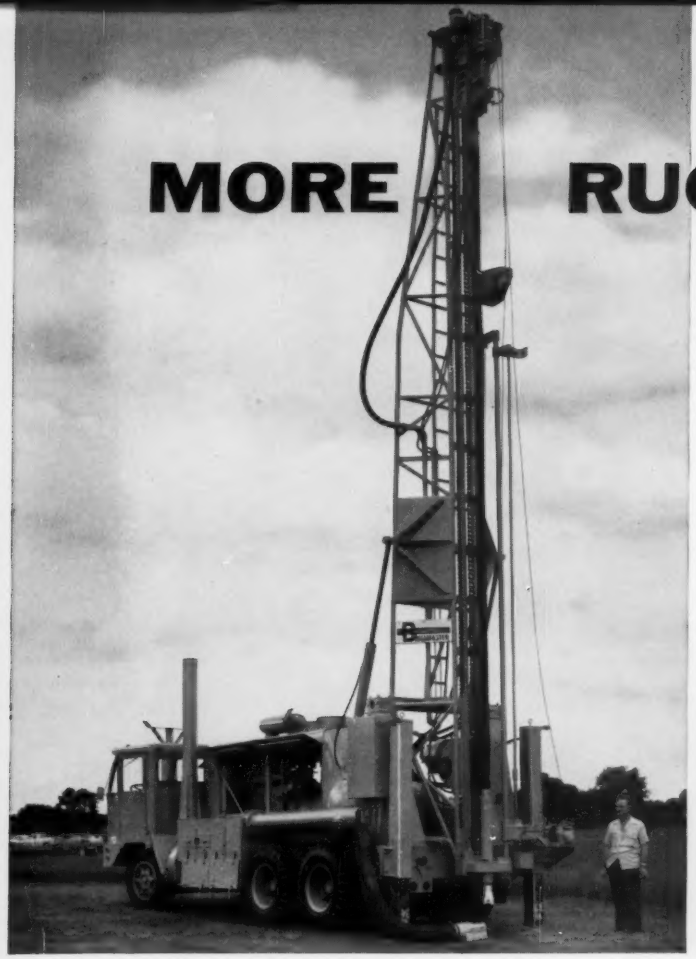

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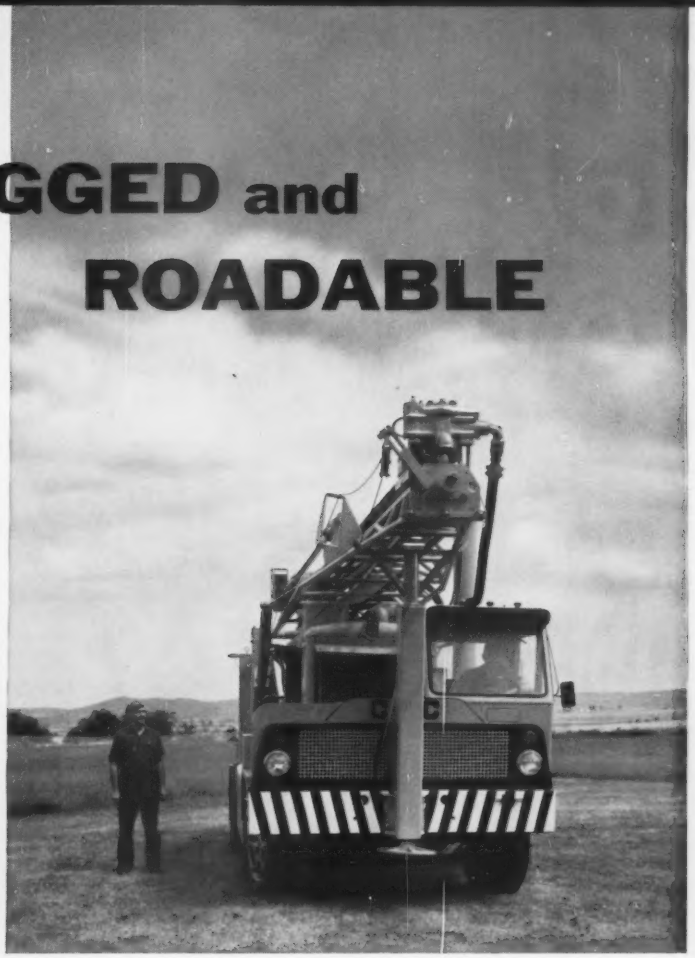

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